A LEVEL-PLAYING FIELD FOR MEDICAL ISOTOPE PRODUCTION -- HOW TO PHASE OUT RELIANCE ON HEU

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ABSTRACT

Two decades ago, civilian commerce in highly enriched uranium (HEU) for use as targets in the production of medical isotopes was considered a relatively minor security concern for three reasons. First, the number of producers was small. Second, the amount of HEU involved was small. Third, the amount of HEU was dwarfed by the quantities of HEU in civilian commerce as fuel for nuclear research and test reactors. Now, however, all three variables have changed. First, as the use of medical isotopes has expanded rapidly, production programs are proliferating. Second, as the result of such new producers and the expansion of existing production facilities, the amounts of HEU involved are growing. Third, as the RERTR program has facilitated the phase-out of HEU as fuel in most research and test reactors, the quantities of HEU for isotope production have come to represent a significant percentage of global commerce in this weapons-usable material. Medical isotope producers in several states are cooperating with the RERTR program to convert to low-enriched uranium (LEU) targets within the next few years, and one already relies on LEU for isotope production. However, the three biggest isotope producers -- in Canada and the European Union -- continue to rely on HEU, creating a double-standard that endangers the goal of the RERTR program. Each of these three producers has expressed economic concerns about being put at a competitive disadvantage if it alone converts. This paper proposes forging a firmer international consensus that all present and future isotope producers should convert to LEU, and calls for codifying such a commitment in a statement of intent to be prepared by producers over the next year. With such a level playing field, no producer would need fear being put at a competitive disadvantage by conversion, or being stigmatized by pressure groups for continued reliance on HEU. The phase-out of all HEU commerce for isotope production could be achieved within about five years.

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INTRODUCTION

The Reduced Enrichment for Research and Test Reactors (RERTR) program was created in 1978 with the goal of phasing out international civilian commerce in bomb-grade, highly enriched uranium (HEU) in order to reduce the risk of such material being diverted or stolen to make nuclear weapons. The chosen strategy was to develop non-weapons usable, low-enriched uranium (LEU) alternatives for such civilian uses and phase out HEU gradually as the alternatives were developed.[2] Over the course of more than two decades, the RERTR program has been successful at phasing out most international commerce in HEU for use as fuel in nuclear research and test reactors. Although this success has been threatened in recent years by several challenges to the RERTR program, it appears that most such challenges are on the way to being resolved.

As the use of HEU as reactor fuel has declined, increasing concern and attention have been focused on the use of HEU in targets for manufacturing medical radio-isotopes. Such commerce in HEU for targets raises dangers of nuclear proliferation and nuclear terrorism for the same reasons as commerce in HEU for reactor fuel. Although civilian HEU is readily usable in nuclear weapons, it is transported thousands of miles and used and stored at commercial plants without the same level of security as government nuclear-weapons facilities.

Two decades ago, civilian commerce in HEU for use as targets in the production of medical isotopes was considered a relatively minor security concern for three reasons. First, the number of producers was small. Second, the amount of HEU involved was small. Third, the amount of HEU was dwarfed by the quantities of HEU in civilian commerce as fuel for nuclear research and test reactors.

Now, however, all three variables have changed. First, as the use of medical isotopes has expanded rapidly, production programs are proliferating. Second, as the result of such new producers and the expansion of existing production facilities, the amounts of HEU involved are growing. Third, as the RERTR program has facilitated the phase-out of HEU as fuel in most research and test reactors, the quantities of HEU for isotope production have come to represent a significant percentage of global commerce in this weapons-usable material.

Medical isotope producers in several states are cooperating with the RERTR program to convert to LEU targets within the next few years, and one already relies on LEU for isotope production. However, the three biggest isotope producers -- in Canada and the European Union -- continue to rely on HEU, creating a double-standard that endangers the goal of the RERTR program. Each of these three producers has expressed economic concerns about being put at a competitive disadvantage if it alone converts. This paper proposes that the solution is to achieve an international consensus under which

[2]Natural uranium includes 0.7% of the fissile isotope U-235; LEU is enriched to less than 20% in this isotope; HEU is enriched to at least 20% of this isotope, and typically 90% or more.

all present and future isotope producers commit to convert to LEU. With such a level playing field, no producer need fear being put at a competitive disadvantage by conversion. This would enable the phase-out of such HEU commerce within about five years.

THREATS TO FUEL CONVERSION RECEDE

Over the last decade, a number of threats arose to fulfilling the RERTR program's primary goal of eliminating civilian commerce in HEU fuel. (1) A large new German reactor was proposed to be built to use HEU; (2) The operators of several reactors that could convert to LEU fuel refused to do so; (3) The United States suspended take back of U.S.-origin spent fuel, which had been a key incentive for operators to convert; (4) The United States suspended fuel development efforts necessary for high-power reactors to convert, and the operators of such reactors expressed resistance to conversion in any case; and (5) Russia and the United States proposed to convert the cores of three Russian production reactors from natural uranium to HEU -- opposite to the practice of the RERTR program -- and in so doing generate five times more HEU commerce than all research reactors worldwide combined.

In the early 1990s, the United States responded with two initiatives. First, the U.S. Congress passed the Schumer Amendment, enacted in 1992, which prohibited exports of HEU unless three conditions were met: (1) the recipient could not use existing LEU; (2) LEU suitable for the recipient was being actively developed; and (3) the recipient committed to convert to LEU as soon as such an alternative was available. Soon after, the United States renewed the take-back of spent U.S.-origin fuel, but barred fuel from reactors whose operators refused to convert to suitable available LEU. Both initiatives were intended to encourage foreign operators to cooperate with the RERTR program. The Schumer Amendment also was intended to spur the renewal of the alternative fuel development program. Based on recent evidence, the U.S. initiatives have succeeded in helping to fend off many of the potential threats to the RERTR regime.

New German HEU Reactor Derailed

In the late 1980s, Germany proposed to build a new, high-flux research reactor, the FRM-II, the first large Western research reactor to use HEU fuel since establishment of the RERTR program. After enactment of the Schumer Amendment, however, the United States informed Germany that Washington could not export HEU to the reactor and that in any case it did not favor any new reactors using HEU. Germany initially chose to continue pursuing HEU fuel and signed a supply contract with Russia, but HEU fuel has yet to be delivered. Last month, German Foreign Minister Joschka Fischer was reported to be actively opposing the use of HEU fuel in the FRM-II and the supply of such fuel from Russia on grounds of German nonproliferation goals, prior commitments, and overall nuclear policy. Germany's federal environment minister also opposes use of HEU fuel in the FRM-II. [1,2] These developments make it less likely that the FRM-II will use HEU fuel and undermine the RERTR regime. Had the Schumer Amendment not

been in place, the United States might well have exported HEU for the FRM-II in the mid-1990s, paving the way for it to start-up with such fuel.

EU Comes Around on Petten

During the 1990s, operators of three reactors that could convert to existing LEU fuel refused to do so: the European Union's HFR Petten, South Africa's Safari, and Germany's FRJ-2 reactors. This year, however, the operator of the Petten reactor completed a feasibility study and announced his intention to convert to LEU fuel. Press reports indicate the main motivation for the switch was concern about supply of HEU fuel, which could not be obtained from the United States under the Schumer amendment without a formal commitment to conversion. [3] South Africa, which has its own supply of HEU, previously resisted conversion to LEU, but recently initiated a new conversion feasibility study to be completed next year. [10] Germany's FRJ-2 has sufficient HEU fuel on hand for the next few years, after which it may shut down.

Back-End Solutions Promote RERTR

The United States renewed the take back of U.S.-origin spent fuel several years ago, but barred fuel from operators who refuse to convert to suitable available LEU fuel. Operators do have the option of contracting for their spent fuel to be reprocessed by Cogema in France, but this facility blends down recovered uranium to LEU, which greatly reduces the risks of theft or diversion, and which prevents operators from sidestepping the Schumer Amendment by recycling HEU. The previous third option of recycling HEU by reprocessing spent fuel at the UK's AEA Dounreay facility is not currently available because the facility has lost its license for such operations and may not regain it. Thus, both of the back-end solutions currently available -- in France and the United States -- promote the goals of the RERTR program.

High-Power Reactors Move toward Conversion

In the wake of the Schumer Amendment, the United States resumed development of advanced, high-density LEU fuels to enable conversion of high-power research reactors that could not convert to existing fuels. Three U.S.-supplied foreign reactors require such advanced fuel to convert, and two of them have committed to convert when such LEU fuel is available. France's ILL-Grenoble last year made such a commitment in an exchange of notes with the United States, apparently to ensure continued HEU fuel supply under the Schumer Amendment until conversion. Since then, France has received HEU fuel from Russia, relieving any immediate supply need, but notably France has not withdrawn its commitment to convert. [4,5] Thus, France still qualifies for U.S. exports of HEU on an interim basis pending conversion to LEU, and need not rely on Russia for future HEU exports. Just a few months ago, Belgium's BR-2 reactor made the same commitment, apparently also because of its desire to receive HEU fuel on an interim basis prior to conversion under the Schumer Amendment. France's Orphee reactor so far has refused any commitment to convert and apparently has sufficient fuel on hand to ignore

the constraints of U.S. export policy. In addition, five operating U.S. research reactors cannot convert to existing fuels. Three of them -- MIT, University of Missouri-Columbia, and NIST -- should be able to convert when advanced LEU fuels are qualified, and are required to do so under a 1986 order by the U.S. Nuclear Regulatory Commission. It is still unclear whether the other two U.S. reactors, the ATR in Idaho and the HFIR in Oak Ridge, will be able to convert to advanced LEU fuels, but further feasibility studies are likely. The Nuclear Control Institute will continue to push for conversion to LEU of all such reactors that can convert, whether located outside or inside the United States.

Russian Core Conversion in Doubt

The Nuclear Control Institute warned at last year's RERTR meeting that the proposal to convert Russia's three remaining weapons-material production reactors to HEU cores would undermine two decades of progress by the RERTR program in reducing international civilian commerce in HEU. [6] The proposal remains a serious threat, but several recent developments suggest it ultimately may be modified to provide for conversion to LEU cores or abandoned entirely. Last year, NCI and seven other non-governmental organizations wrote to U.S. vice-president Al Gore, urging him to abandon the HEU core conversion plan in favor of LEU. This April, Gore replied that the United States would continue to pursue "HEU fuel for the initial cores," apparently to avoid any delay in conversion, but he acknowledged concerns about HEU by pledging to "concurrently pursue the development" of LEU cores. [7] More recently, the entire core-conversion initiative has been called into question by Russian concerns about the safety of the three aged reactors, especially if converted to HEU cores prior to full-scale, two-year irradiation testing of the new HEU fuel that represents a radical departure from the existing fuel design. [8] The result is that Russian core conversion will at least be delayed significantly, which provides time to fully test LEU and adopt it for the initial cores. NCI and others are urging Washington and Moscow to pursue this course. However, the entire controversy may become moot if conversion is abandoned due to Russian safety concerns.

Summary of Fuel Conversion Status

Due to these recent developments, the RERTR program's fuel conversion efforts have attained unprecedented success. Annual U.S. exports of HEU fuel have declined from a peak of nearly three metric tons in the 1960s, to 1.5 tonnes in the year prior to establishment of the RERTR program, to zero during the past six years. Such exports may be renewed for an interim period during the next few years to provide fuel to reactors that have committed to convert but cannot yet do so. However, such renewed HEU exports would be provided only to facilitate a permanent end to such commerce.

Out of 65 high-power research reactors originally located in or supplied by the United States, only two have rejected the conversion norm outright – France’s Orphee and Germany’s FRJ-2. Moreover, in light of recent progress in advanced fuel

development and moves toward conversion by several high-power reactors, it is conceivable that within five to ten years, all Western reactors will have converted to LEU or shut down, except perhaps for France's Orphee and as many as two U.S. government reactors (depending on the outcome of conversion feasibility studies). This could reduce commerce in HEU fuel for Western research reactors to less than 100 kilograms annually.

HEU COMMERCE FOR MEDICAL ISOTOPE PRODUCTION

Two decades ago, HEU commerce for medical isotope production was small and relatively insignificant in comparison to the large quantities used as fuel by research and test reactors. Since then, however, the RERTR program has been reducing HEU commerce for reactor fuel, while commerce for isotope production has been growing as such isotopes are increasingly used routinely for diagnosis and treatment of illness by more countries. As a result, the quantities of HEU used for isotope production have become a significant and growing share of worldwide civilian commerce in HEU.

At least seven states currently produce such isotopes -- Argentina, Australia, Belgium, Canada, Indonesia, the Netherlands, and South Africa. Of these, only Australia relies on LEU targets, employing 2.1%-enriched uranium to produce isotopes for its domestic market and neighboring states. All other producers continue to rely on HEU, employing a total of approximately 50 kilograms of HEU targets annually, typically enriched to the 93% bomb-grade level. This level of HEU commerce could well grow as current manufacturers increase production and at least three other states -- Russia, South Korea, and the United States -- prepare to commence isotope production.[3] Unless such reliance on HEU is reduced, therefore, medical isotope production could soon be responsible for the majority of international commerce in bomb-grade uranium. It thereby would represent the main threat to success of the RERTR program.

Status of Conversion Efforts and Commitments

For several years, the RERTR program has been working to develop LEU alternatives for medical isotope production. The task is complicated by the fact that most isotope producers have a unique target design. In addition, two opposite production processes are in commercial use, one relying on acid and the other on base dissolution. However, Australia's successful experience with LEU targets demonstrates that production of medical isotopes with such proliferation-resistant uranium is feasible. The task ahead is to develop targets and processes for the other isotope producers that permit large-scale production at acceptable purity levels.

Among existing small-scale producers, efforts are farthest along with Indonesia, which has successfully irradiated and processed prototype LEU targets relying on the acid process, and should be ready for full-scale production within two years. Argentina

[3]Brazil also is developing the capacity to produce medical isotopes, but is relying on a new technology that avoids uranium targets entirely and instead irradiates Molybdenum-98.

likewise is cooperating with the RERTR program, and plans to convert to LEU targets within three years, relying on the base process which is slightly behind in research and development.[4] The RERTR program also is working with Australia to improve the efficiency of its production, which already relies on LEU, by increasing enrichment to the still low-enriched 19.75% level. South Africa has expressed willingness to discuss conversion of its targets, despite having its own stock of HEU and thus being immune from supply pressures that have motivated others to embrace conversion.

The RERTR program also has made progress with future producers. South Korea has a cooperative agreement with RERTR to focus on development of LEU targets and has withdrawn a request for HEU. Russia is planning to commence production of isotopes with a new liquid-core reactor technology based on HEU, but subsequently intends to explore LEU alternatives. The United States likewise was planning to start production with HEU targets at Sandia and then convert to LEU, but the entire initiative is now stalled for lack of funding.

Unfortunately, least progress has been made with the largest producers -- Institut National des Radioelements (IRE) in Belgium, MDS Nordion in Canada, and Mallinckrodt in the Netherlands -- which are responsible for perhaps 90% of HEU commerce associated with medical isotopes. During the last year, some signs of cooperation have begun to appear, motivated apparently by these producers' concerns about future supplies of HEU, which cannot be obtained from the United States under the Schumer Amendment unless they commit to convert and cooperate actively in an LEU target development program. Belgium's IRE has volunteered to irradiate and process prototype LEU targets but without making any commitment to convert. The Netherlands' Mallinckrodt also recently expressed an interest in cooperating with RERTR, perhaps because it has lost its former source of HEU with the shutdown of recycling operations at AEA Dounreay.

Among the big producers, the most substantial conversion commitment was made this year by Canada's MDS Nordion, in the context of its export license request for HEU from the United States. However, the commitment came only after an intervention in the licensing proceeding by the Nuclear Control Institute prompted the U.S. Nuclear Regulatory Commission (NRC) to call a rare public meeting at which NCI, Nordion, and the U.S. government testified.. Under this close scrutiny, Nordion committed to convert to LEU targets, which it said was feasible and would require approximately three to five years. On the basis of that commitment, the NRC approved a five-year HEU export license to Nordion to permit isotope production to continue in the interim. However, the Commission insisted that the Canadians and the U.S. Executive Branch submit a "yearly status report detailing the progress of the program and Canadian cooperation in developing LEU targets." The NRC also issued a stern warning to Nordion to live up to its conversion commitment, stating: "If the Commission should make a finding, following

[4]Argentina recently has indicated some interest in switching to the acid process, which should not delay its conversion to LEU because the acid process is further along in development. The LEU base process still would be developed by the RERTR program for other producers who prefer that process.

review of these periodic status reports and a public meeting if necessary, that the requirements of the Schumer Amendment are not being met, the Commission may modify, suspend, or revoke the license . . ."[5] [9]

Continuing Economic Concerns

Nevertheless, all three major producers continue to cite economic costs as a potential obstacle to conversion. Nordion has been most explicit, stating that it will resist conversion if doing so would produce a "large percentage increase in total operating cost for the reactor and associated processing equipment for medical isotope production." Mallinckrodt and IRE have expressed similar reservations in private.

Concerns about cost arise because LEU targets generally contain five times as much uranium as HEU targets for the same output of isotope. The uranium cost is negligible, but tanks and processing lines may need to be modified to hold up to five times as much volume, and/or equipment may need to be modified to accommodate higher-concentration uranium solutions. Such modifications are not a significant expense for future producers that have yet to introduce radioactive materials to processing facilities, but could be for existing producers if required to modify radioactive facilities.

It is possible that modifications required of existing producers would be neither extensive nor expensive. For example, the RERTR program's initial studies for Canada indicate that LEU may be soluble at five times the concentration used for HEU, so that processing volume would remain constant and no major modifications would be needed in tank capacity or waste processing equipment. Likewise, it is possible that existing equipment can process uranium at such higher concentrations to extract medical isotopes while maintaining acceptable purity levels and process rates. If this proves the case for Canada and the other two major producers, there will be no obvious economic hurdle to conversion.

However, it is also possible that conversion to LEU by existing producers may turn out not to be cost-free. If radioactive equipment must be modified or replaced to accommodate the higher process volumes or uranium concentrations associated with LEU targets, significant expenses could be incurred. It is this concern apparently that has deterred the major producers from making firm commitments to convert. In a competitive market, none of the three wants to be the only one to convert and incur such expenses, and thereby put itself at a competitive disadvantage relative to the others.

The solution is straightforward. A firm international consensus should be forged that all existing and future isotope producers will convert to LEU. If all convert, none need fear being put at a competitive disadvantage by the potential expense, and the

[5]The Commission acknowledged the important role of the Nuclear Control Institute in spurring Canadian cooperation, stating: "At the time NCI filed its pleadings with the Commission, the continuing existence and extent of an active program to develop LEU targets for use in the [Canadian] MAPLE reactors were not readily apparent."

economic deterrent to conversion will be mitigated. As with RERTR's fuel-conversion program, the switch to LEU targets should be phased in as substitutes are developed, and no new facilities should be built to use HEU. This would permit the expeditious phase-out of such HEU commerce without interrupting the supply of vital medical isotopes.

LEU targets processed by acid dissolution are less than two years away from commercial introduction. Those processed by base dissolution are perhaps a year behind. Individual modifications for each unique target and process may require an additional year or two of work by producers in conjunction with the RERTR program. Thus, conversion of all existing and future medical isotope production to LEU targets should be feasible within five years. Annual commerce in about 50 kilograms of HEU associated with isotope production would be prevented from growing and then phased out, helping to facilitate the RERTR program's goal of eliminating all such commerce.

A CALL FOR RESPONSIBLE ACTION

To summarize, HEU targets for production of medical isotopes, which two decades ago represented a small fraction of global civilian HEU commerce, may soon represent the majority of such commerce unless responsible action is taken. Conversion to LEU targets is feasible, as Australia and Indonesia have demonstrated. Most small-scale and future producers already plan to convert to LEU. The main problem is the three big producers, who have cited economic concerns against conversion. However, based on initial research, the economic costs of conversion likely will be smaller than once feared. In any case, the main concern about increased cost -- reduced competitiveness -- can be addressed if all producers commit to convert.

Consequently, the Nuclear Control Institute calls on all producers of medical isotopes, and especially the three main producers responsible for most HEU commerce, to forge a consensus on universal conversion to LEU targets, with the aim of converting within approximately five years. Such a consensus could be codified by a joint statement of intent, prepared over the course of the next year and presented formally at the 23rd international meeting of RERTR in the year 2000. For illustrative purposes, a potential draft statement is attached below, but the actual statement would have to be written and signed by the producers themselves. Such voluntary universal compliance would also avert likely efforts by pressure groups to stigmatize producers who refuse to convert to LEU. By forging a consensus for conversion, medical isotope producers could thus help to ensure an uninterrupted supply of vital medical isotopes while avoiding risks of nuclear proliferation and nuclear terrorism, a momentous achievement for the start of a new millennium.

DRAFT STATEMENT OF INTENT

We, the undersigned current producers and planned producers of medical radio-isotopes,

NOTING THAT --

(1) Highly enriched uranium (HEU) is a fissile material that can be used to make nuclear weapons;

(2) For more than twenty years, an international consensus has propelled efforts to phase out civilian uses of HEU as quickly as possible, in order to prevent its diversion or theft for nuclear weapons, by developing and substituting specially designed low-enriched uranium (LEU) that is unsuitable for nuclear weapons;

(3) Global civilian commerce in HEU has been and continues to be significantly reduced by the conversion of nuclear research and test reactors from HEU fuel to LEU fuel;

(4) The use of HEU targets for the production of medical radio-isotopes is now a significant and growing share of global civilian commerce in HEU;

(5) Commercial production of such isotopes can be accomplished with LEU targets, as demonstrated by one producer's current reliance on LEU targets;

(6) Commercial production that relies on HEU targets can in principle be converted to reliance on LEU targets without interrupting the supply of vital medical isotopes;

(7) The development of specific LEU target designs and processes for individual isotope producers can in principle be accomplished within several years;

(8) Conversion from HEU to LEU targets will promote international efforts to prevent nuclear terrorism and nuclear proliferation, and will facilitate the uninterrupted supply of vital medical isotopes; and

(9) Conversion to LEU targets will be facilitated if <u>all</u> current and planned isotope producers convert as quickly as possible, so that no producer can gain a potential competitive advantage by avoiding conversion.

DO HEREBY PLEDGE --

(1) To convert as quickly as possible from HEU to LEU targets for the production of medical radio-isotopes; and

(2) To actively develop and/or cooperate in the development of specific LEU target designs and processes for our own production of medical isotopes, in order to enable such expeditious conversion.

REFERENCES

[1] Christian Schwagerl, "Foreign Ministry Rejects Uranium Import From Russia; Change of Course Could Delay Garching Reactor," *Berliner Zeitung*, September 10, 1999.

[2] Mark Hibbs, "German Foreign Minister Weighs in Against FRM-2 HEU Use," *Nuclear Fuel*, September 20, 1999, pp. 3-4.

[3] Ann MacLachlan, "Petten Director Says Study Clears Way for Start of LEU Conversion this Summer," *Nuclear Fuel*, May 31, 1999, p. 6.

[4] Ann MacLachlan, "U.S. May Resume HEU Fuel Supply as France's ILL Studies Conversion," *Nuclear Fuel*, November 30, 1998, p. 3.

[5] "Enriched Uranium Delivered to France for Use in Research Reactors," *Interfax News Agency*, Moscow, in *BBC Summary of World Broadcasts*, January 1, 1999.

[6] Alan J. Kuperman and Paul L. Leventhal, "HEU Core Conversion of Russian Production Reactors: A Major Threat to the International RERTR Regime," presented at 21st International Meeting of RERTR, Sao Paulo, Brazil, October 1998.

[7] Letter from U.S. Vice President Al Gore to NCI senior policy analyst Alan Kuperman, April 19, 1999.

[8] Michael Knapik, "Licensing Issues Could Delay Conversion of Russian Pu-Production Reactors," *Inside N.R.C.*, September 13, 1999.

[9] "Memorandum and Order," Nuclear Regulatory Commission, Docket # 11005070, License No. XSNM-03060, CLI-99-20, June 29, 1999.

[10] G. Ball, “South Africa and the RERTR Programme: Current Status * An AEC Perspective,” presented at 22nd International Meeting of RERTR, Budapest, Hungary, October 1999.